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GROUND MOTION TRANSDUCER PLACEMENT SYSTEM.(U)

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GROUND MOTION TRANSDUCER PLACEMENT SYSTEM

AIR FORCE WEAPONS LABORATORY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FEBRUARY 1977

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GROUND MOTION TRANSDUCER PLACEMENT SYSTEM

February 1977

Final Report

Approved for public release; distribution unlimited.

AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base, NM 87117

AFWL-TR-76-310

This final report was prepared by the Air Force Weapons Laboratory, Kirtland AFB, NM, under Job Order 10882109. Mr. David J. Fogelson was the Laboratory Project Officer-in-Charge.

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During the high explosive simulation testing, it was determined that the placement system used to install free field motion transducer cansisters had discrepancies which limited the accuracy with which the cansiters could be placed and, thus, effected data accuracy. Therefore, a program was initiated to evaluate the various placement systems in use or previously used and to propose changes or new designs. The criteria used for new designs were the following: (1) placement accuracy within at least one degree for all orthogonal (over)

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axes, (2) the device to be removable from the cured grout which holds the canister in place, (3) a waterproof assembly, (4) shock hardened, to avoid damage caused by rough handling, and (5) lightweight, to allow expedient field operation. In-house research produced the concept of using inclinometers to provide 2-axis leveling in a placement tool at a point just above the canister and keyed extensions to provide above-ground azimuth alignment. This new design will result in higher quality data. The development, evaluation efforts, and operation procedures are discussed.

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ILLUSTRATIONS

SECTION I

INTRODUCTION

The Civil Engineering Research Division, Air Force Weapons Laboratory, has been engaged in ground motion measurements induced by high explosive detonations. There have been problems in placing the ground motion transducers with accuracy; therefore, confidence in the data required was somewhat limited.

A placement system is a device to install ground motion transducer canisters in bore holes in a high explosive test bed. The system should provide accurate alignment of the gage axes and be light and easy to use in field operations.

Since the placement system in use did not provide the accuracy needed, an in-house project was initiated to survey existing placement systems and make changes or design a new system.

SECTION II

SURVEY OF EXISTING PLACEMENT SYSTEMS

The initial task of this program was to identify and evaluate the various placement systems in use or previously used. The criteria for the evaluation were the following: (1) canister placement accuracy within one degree for each of the three orthogonal axes, (2) a waterproof assembly capable of being removed from cured grout, and (3) shock hardened, to avoid damage by rough handling; and lightweight, to allow expedient operation in the field.

The placement system most recently used by the Air Force Weapons Laboratory was very simple. It consisted of a 5-foot long, 1-inch diameter aluminum rod with an indexed thread on one end and a square tube on the other (figure 1). The square tube end was attached to additional 10-foot lengths of aluminum square tubes to accommodate placement at various depths. Any leveling that was required, such as velocity gage canister installation, had to be accomplished using the output of the gage itself. When placing canisters containing accelerometers, there was no way of determining the level position of the canister. Another problem with this system was indexing the canister to the placement rod. When the canister was screwed into the placement tool, the ground zero (GZ) ridge on the canister did not always line up with the flat on the square tubing. An adjustment was made by placing a shim(s) between the tool and canister until the proper alignment was achieved. This system limited the confidence in the data due to uncertainty of the position of the transducer axes.

There have been a number of specialized placement systems designed and built by the Air Force Weapons Laboratory (AFWL) in recent years. One of these systems was a pneumatic release device which was designed to operate in a dry environment where native soil was used to backfill the instrumentation holes. It released a canister without disturbing it. However, it was not waterproofed, nor did it provide leveling. Therefore, this design did not meet the criteria.

Another special application system was designed and fabricated by AFWL for placing canisters in 45° slant holes. This placement tool incorporated two pendulum potentiometers which provided very accurate alignment. It was waterproof and reasonably lightweight but had one major drawback. The pendulum potentiometers were rather large and located close to the canister. A slight overfill of grout would anchor the tool as well as the canister in the instrumentation hole.

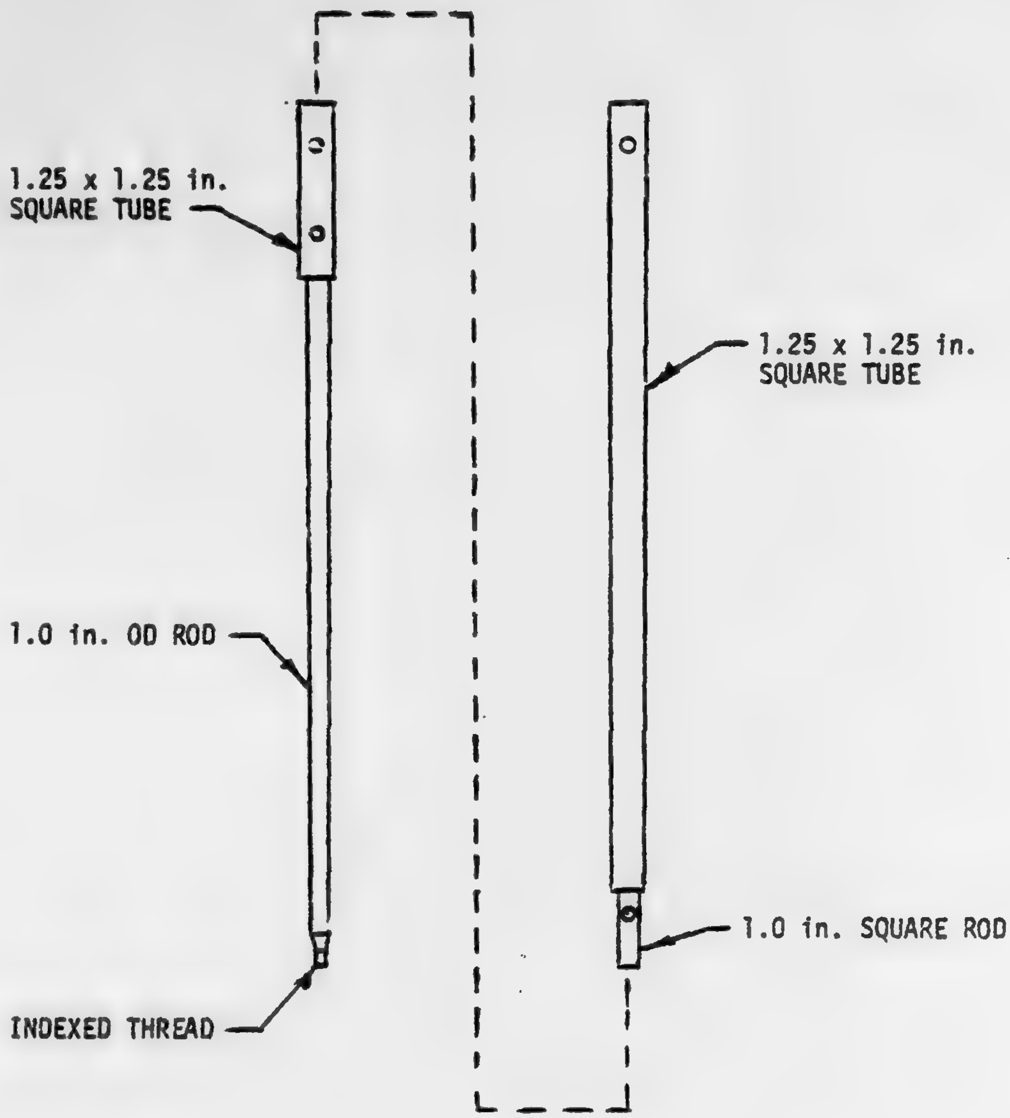


Figure 1. Placement System by Use of Square Tubing

An earlier design that was tried by AFWL was a unique servo leveling system that used a two-axis mercury leveling sensor to control two electric actuators (reference 1). The actuators moved the bottom section of the tool and, thus, the canister. This was another system that was designed for canister placement in a dry environment and the use of native soil for backfill. This system could not be used underwater nor with grout.

None of these systems met the desired criteria. However, these approaches should be kept in mind for future use in specialized applications.

1. Robinson, Michael G., Velocity Gage Placement Tool, AFWL-TR-67-117, Air Force Weapons Laboratory, Kirtland AFB, NM, January 1968.

SECTION III

DEVELOPMENT OF THE NEW PLACEMENT SYSTEM

The initial problem addressed in the design of a new placement system was to find a level indicator. The requirements for the level indicator were as follows: (1) lightweight, (2) small, (3) powered by batteries, (4) resistive device, (5) accuracy to 0.25 degree, (6) linear through a range of $\pm$10 degrees.

The search produced a large number of servo devices that required 400 hertz power and a few resistive devices such as pendulum potentiometers. The only pendulum potentiometers with the required accuracy were quite large, 2.52 diameter by 1.3 inches deep. This would require a large housing which could easily be cast in grout and could not be removed from the hole.

The device selected, finally, was a servo inclinometer manufactured by Shaevitz Engineering which had the specifications listed in table 1. One of these units was purchased and tested and met all published specifications. The unit was subjected to impacts of 500 g several times and checked each time. The worst effect was a zero offset of 0.003 volts. It was decided that two of these units would be incorporated in the new placement system. The final design of the placement system is shown in figure 2. Refer to List of Drawings (table 2) for documents with more detail.

Table 1

INCLINOMETER SPECIFICATIONS

Manufacturer:	Schaevitz Engineering P.O. Box 505 Camden, NJ 08101

Model: LSRP-14.5

Size: 1.43" dia x 1.35" high

Range: ±14.5°

Input Voltage: Balanced ±12 VDC

Full Range Output Voltage: ±5.0 VDC

Zero Offset: Less than 0.1% of full scale

Operating Temperature: 0°F to 180°F

Linearity: ±0.02% full scale

Cross Axis Sensitivity: 0.5%

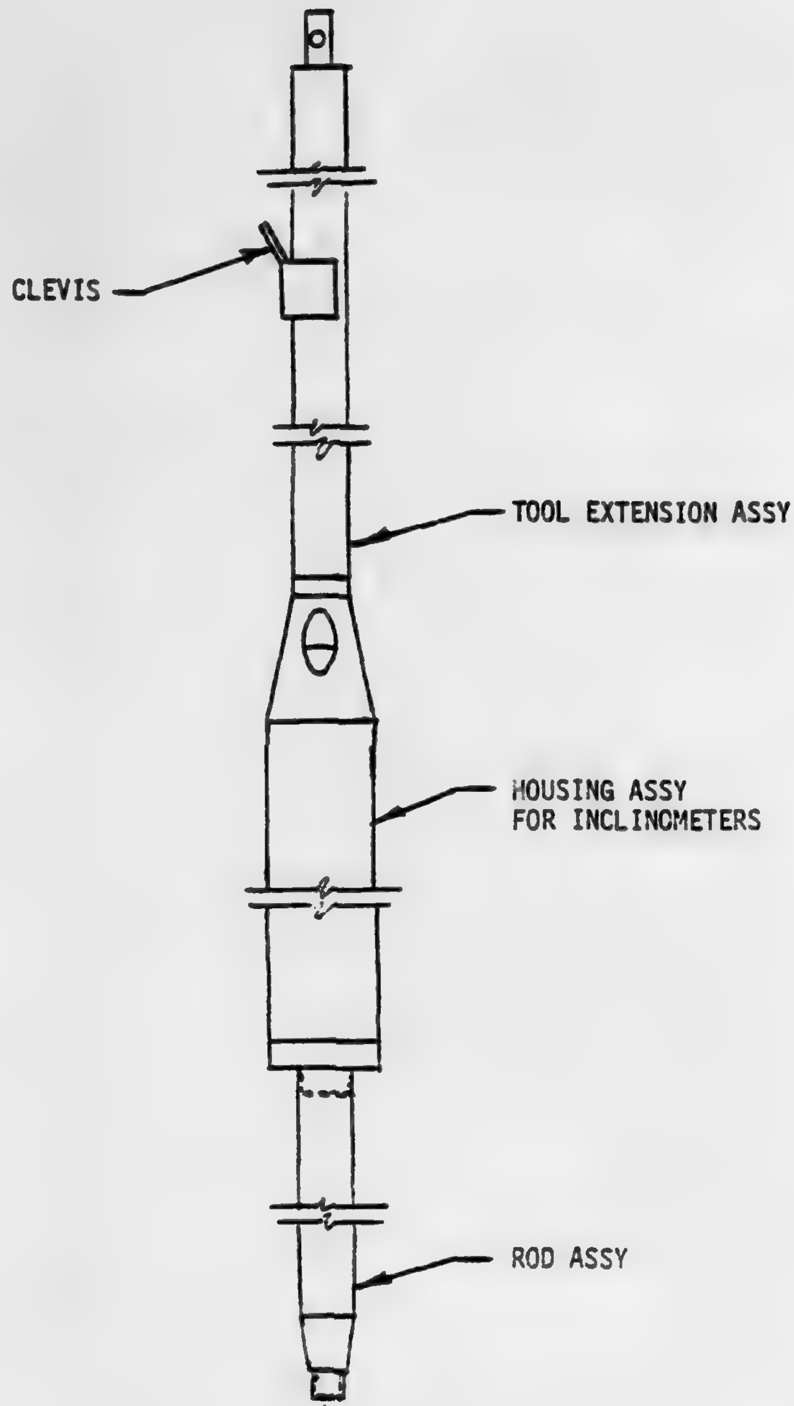


Figure 2. Placement Tool

Table 2

LIST OF DRAWINGS

Placement Tool Assemblies	7413340
Housing Assembly Inclinometer, 90°	7413335
Plug, Upper	7413338-01
Adapter, Upper	7413337-01
Housing	7413336-04
Housing	7413336-01
Plug Lower	7413334-01
Housing Assembly Inclinometer 45°	7413345
Plug	7413347-01
Base	7413346-01
Adapter	7413337-01
Housing	7413316-03
Housing	7413316-01
Extension Assembly	7413344
End Assembly	7413343-01
Tube	7413342-03
Tube	7413342-01
End	7413341-01
Clevis	7413315
Rod Assembly, Placement	7413339
Nut Locking	7413333-01
Adapter, Lower	7413332-01
Rod	7413331-01
Tip	7413599-01
Holder Assembly	7413310
Screw Assembly	7413314-10
Hinge	7413313-01
Holder, Assembly Left Hand	7413312-10
Holder, Right Hand	7413311-01
Tripod Assembly	7413350
Head Assembly	7413349-10
Leg Assembly	7413348-10
Centering Device Assembly	7413595
Plate	7413597-01
Spring	7413596-01
Block	7413594-01

These drawings are available from:

AFWL/DYE, Kirtland AFB, NM 87117

SECTION IV

PLACEMENT SYSTEM OPERATION

The operation of the placement system is quite simple. Besides the tool itself, two 12-volt batteries and two portable digital voltmeters are required. The connections required are shown in figure 3. After the connections are made, a quick functional check can be performed by tilting the placement tool through the vertical on both orthogonal planes and noting the digital voltmeter readings to check polarity.

After the functional check of the tool, the next step is to screw the canister onto the tool and hand tighten it. If the ground zero ridge does not line up with the scribe mark on the tool, loosen the locknut, rotate the rod and canister until the ridge is properly aligned, and tighten the locknut again. The canister is now ready to be installed.

Make sure there are enough extensions on hand to lower the canister to the proper depth and then begin to lower the canister into the instrumentation hole. If the canister is to be placed very deep, a winch and clevis are available to take the weight and facilitate the work. A holder has been provided to clamp around the tool to hold the canister at the proper depth while grouting. When the canister is at the proper depth, check the digital voltmeters to determine if the canister is level. If not, tilt the placement tool to obtain the proper leveling. If the canister cannot be leveled due to irregularities in the bore hole, level it as closely as possible and record the final position after the grout has cured.

The azimuth alignment must be maintained during the grouting. The simplest and most effective way to do this is to position a transit at ground zero and sight on the placement rod extensions. It is easy to turn the tool until the scribe line is centered on the extension as viewed through the transit. Refer to figure 4 for tool output polarity.

An alternate method of azimuth alignment is one which has been employed by the AFWL on previous placement devices. This was simply by use of a 4-power telescopic rifle sight mounted on an adapter that was keyed for azimuth alignment. The procedure was to lower the canister to the proper depth, the scope placed on the tool and sighted on a ground zero surveyor's stake. This worked as well as the previously mentioned method; but at times the top of the tool, where the scope

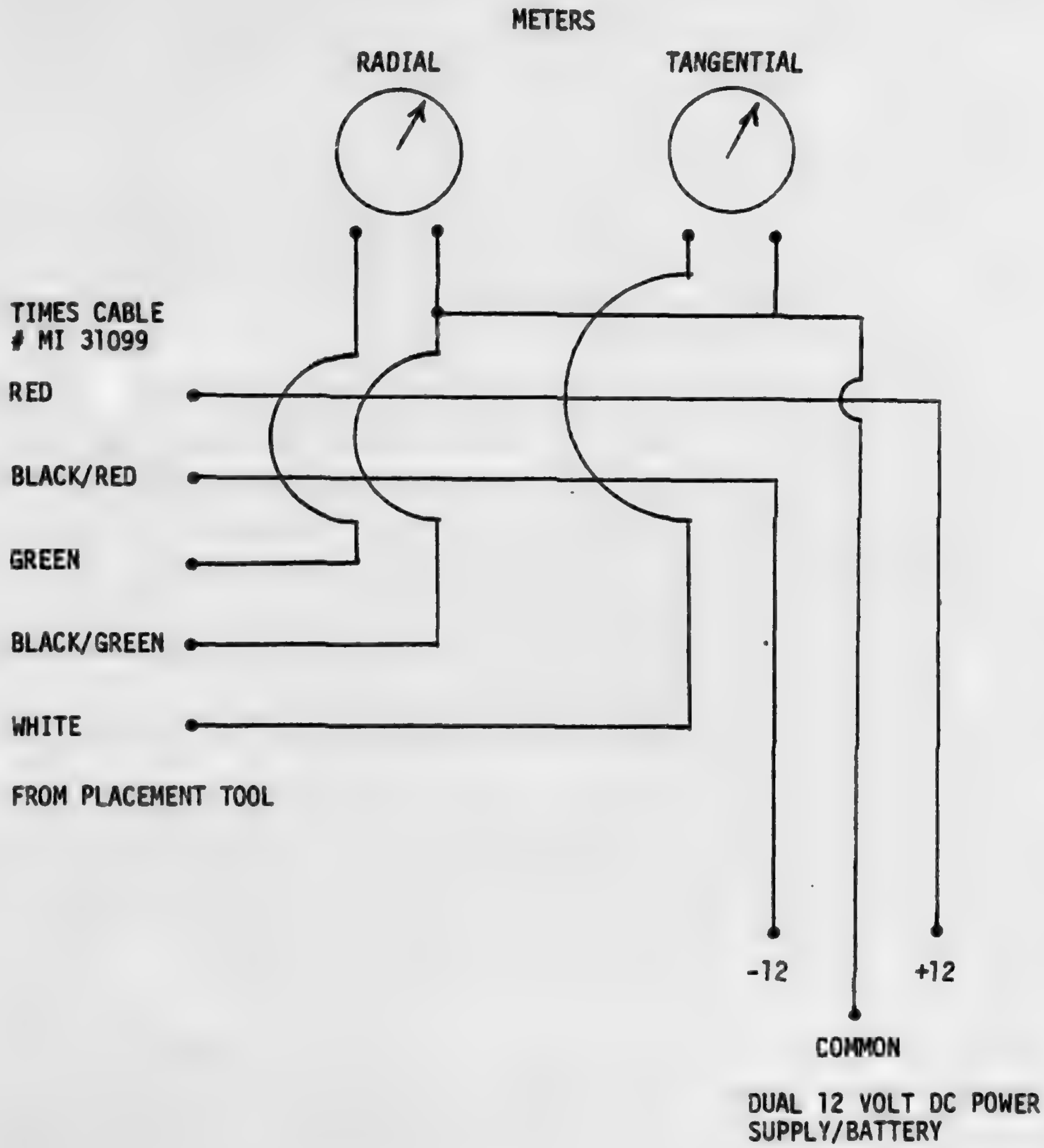
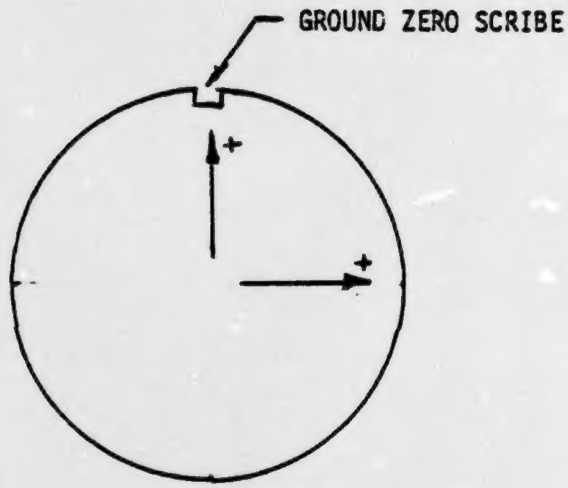


Figure 3. Placement Tool Wiring System



VIEW LOOKING DOWN AT TOOL
(INCLINOMETER OUTPUT WHEN TOP TILTED AS SHOWN)

Figure 4. Tool Output Polarity

was mounted, would end up at an inconvenient height--either too high or too low for convenient sighting by field personnel.

After the grout has cured, the level and azimuth alignment should be checked. Any deviation should be noted on the channel history sheets. To remove the tool, it is turned counterclockwise until the threads are disengaged and the tool is pulled out of the hole. Each time the placement system is used, it should be cleaned and checked for any problems.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This new placement system can provide canister alignment accuracy within at least 0.25 degree. This is a significant improvement over any system previously used. It is a reasonably lightweight device that is waterproof and was designed to be used when placing ground motion canisters in grout. With this system there is greater confidence in the data retrieved from high explosive induced ground motion due to a more precise knowledge of the orientation of the gage axes.

RECOMMENDATIONS

An improvement to the placement system that would make it easier and simpler to use would be to design and build a box containing a pair of center-zero meters with batteries and battery charger to operate the system. This would allow the meters to be calibrated to read degrees of tilt directly and provide power for the system. The batteries would have to be charged overnight.

This placement system has application as a borehole profiler. With light spring centering devices attached as shown in figure 5, the tool could be lowered into a bore hole and inclinometer readings taken every five feet. The excursion of the bore hole could then be plotted. The centering device has been designed (table 2) but has not been field tested.

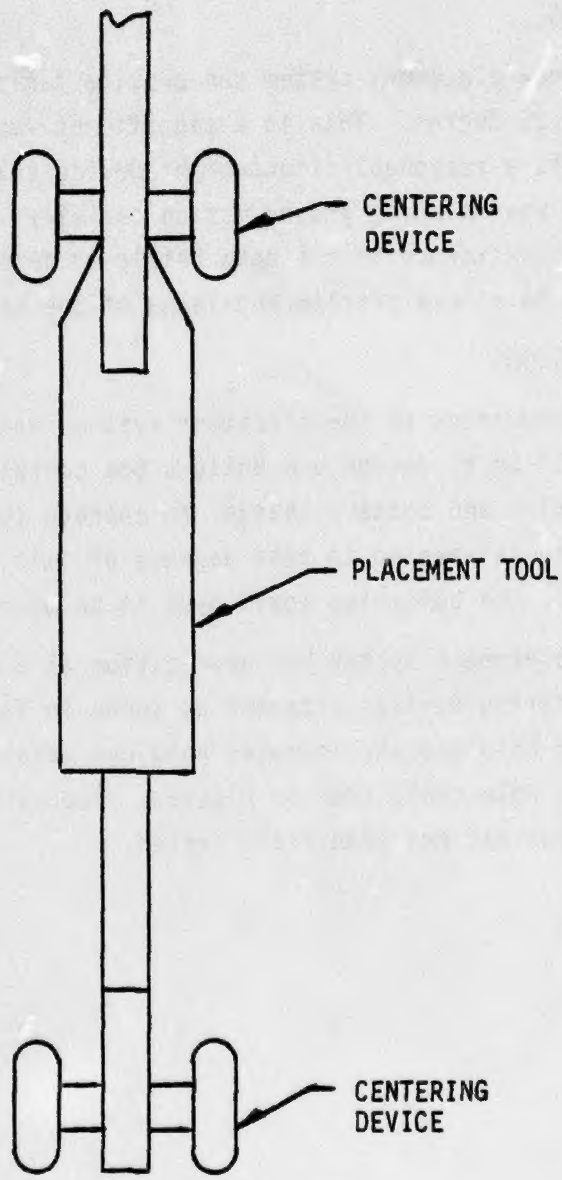


Figure 5. Placement Tool as Profiler